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Component comprising a masking layer

The invention relates to a component in accordance with the preamble of claims 1 and 3.

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Components, such as for example turbine blades and vanes, in particular for gas turbines, are coated in particular in the main blade region, since they are exposed to high thermal loads.

- 10 Lower temperatures prevail in the base or securing region of the turbine blade or vane, and consequently there is no need for a coating in the form of a thermal barrier coating there. Ceramic coatings are even undesirable in this region, since the base has to be  
15 fitted accurately into a metallic disk.

- Masks in accordance with the prior art which are intended to prevent coating are often difficult to remove again, since the material of the mask bonds well  
20 to the base material of the turbine blade or vane or there is an undesired diffusion of elements out of the masking layer into the base material of the turbine blade or vane.

- 25 Therefore, it is an object of the present invention to provide a masking layer which, following desired coating of the turbine blade or vane, can easily be removed again in the undesired regions without the base material or the geometry of the turbine blade or vane  
30 being affected in the masked region.

- The object is achieved by a turbine blade or vane as described in claim 1. A ceramic is applied direct to the base material of the turbine blade or vane.

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Thermal barrier coatings which are applied to a turbine blade or vane in the main blade region generally have

intermediate layers between a substrate, i.e. the base material of the turbine blade or vane, and the thermal barrier coating, such as for example what are known as bonding layers, for example metallic MCrAlY, or  
5 diffusion barriers.

These intermediate layers are dispensed with at the masking in order to prevent good bonding of the masking layer. The masking layer is formed in particular from ceramic, since the brittle ceramic can be removed by  
10 simple processes, such as for example sand blasting, dry ice blasting. The material for the ceramic is selected in such a way that there is little or no diffusion from the ceramic into the substrate.

15 The object of the invention is also achieved by a turbine blade or vane as described in claim 3. The masking layer reacts with the material of the material that is to be applied and is therefore easy to remove.

20 Further advantageous configurations of the component according to the invention as described in claims 1 and 3 are listed in subclaims 2 and 4 to 14, respectively.

In the drawing:

25 Figure 1 shows a turbine blade or vane in accordance with the prior art,

Figure 2 shows process steps involved in the production of a coating in accordance with the prior art,

Figure 3 shows a masking layer of a turbine blade or  
30 vane according to the invention,

Figure 4 shows a further masking layer of a turbine blade or vane according to the invention,

Figures 5, 6 show a masking layer which reacts with material of layers which are to be applied, and

35 Figures 7, 8 show how the masking layer can easily be removed again following a reaction.

Identical reference numerals have the same meaning throughout the various figures.

5 Figure 1 shows a perspective view of a turbine blade or vane 1, in particular a rotor blade for a gas turbine, which extends along a longitudinal axis 4. In succession along the longitudinal axis 4, the turbine blade 1 has a securing region 7, an adjoining blade platform 10 and a main blade region 13.  
10 The securing region 7 is designed as a blade root 16 which is used to secure the turbine blade 1 to a shaft (not shown in more detail) of a turbine machine (likewise not shown in more detail). The blade root 16  
15 is designed, for example, in the form of a hammerhead. Other configurations, for example as a fir-tree root or dovetail root are also possible.

In conventional turbine blades 1, solid metallic materials, in particular nickel- or cobalt-base superalloys, are used in all regions of the turbine blade. The turbine blade may in this case be produced by a casting process, by a forging process, by a milling process or by combinations of the above.

25 In particular the securing region 7 is made from metal, since this region is clamped in an accurately fitting manner into a corresponding shape in a disk. Brittle ceramic coatings would flake off and alter the geometry  
30 in the securing region.

The main blade region 13 is coated, for example, with a thermal barrier coating, it being possible for further layers, such as for example bonding layers (MCrAlY layers), to be arranged between the base material of  
35 the turbine blade 1.

A component according to the invention in the form of a turbine blade or vane 1 may be a guide vane or rotor blade of any desired turbine, in particular a steam or  
5 gas turbine.

Figure 2 shows what happens when the surface of the blade 1 does not have a masking layer 25 (Fig. 3). The material 22 of an interlayer 19 (MCrAlY), which has  
10 been applied in any desired form to a surface of the turbine blade 1, for example by plasma spraying, by PVD or CVD or by dipping in a liquid metal or application of powder, so as to form the interlayer 19, leads to a reaction of the material 22 with the turbine blade 1  
15 and to good bonding of the interlayer 19 to the base material of the turbine blade 1.

When the interlayer 19 is to be removed again, for example because it is undesired in the securing region 7, it therefore presents considerable problems, since  
20 the geometry of the securing region 7 changes as a result of partial removal of the base material of the substrate 40.

Figure 3 shows a component according to the invention in the form of a turbine blade 1 with a masking layer 25. By way of example, first of all a first functional layer 28 is applied to the turbine blade 1. This first functional layer is, for example, a polycarbosilane layer with a thickness in the nanometer range, which  
30 crosslinks at 200°C in air, allowing good bonding to the base material 40 of the turbine blade 1.

By way of example, a gradient layer 31 is applied to the first functional layer 28, the material used for  
35 the gradient layer 31 being a mixture of polysiloxane and a metal-ceramic and/or metal.

The gradient layer 31 may, for example, be applied in

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the form of a slip with layer thicknesses of 10-30  $\mu\text{m}$   
and can likewise be crosslinked at approximately 200°C  
in air.

- A further powder, in particular of the composition MCrAlY, where M stands for Fe, Co, Ni, is added as a metallic filler to this material of the gradient layer
- 5 31, since such a filler, on account of its expansion coefficient, is used as an interlayer (bonding layer) between base material 40 and ceramic thermal barrier coating.
- 10 A reactive layer 34, consisting, for example, of a pure carbon precursor, is applied to the gradient layer. The crosslinking within the reactive layer 34 takes place at 180°C in air.
- 15 The crosslinked layers 28, 31, 34 are converted into a ceramic by what is known as the pyrolysis process as a result of a heat treatment at 1000°C under an argon atmosphere. On account of the change in density of the organometallic precursor, such as for example the
- 20 polysiloxane, having a density of 1 g/cm<sup>3</sup>, to a silicon oxycarbide phase (SiOC) with a density of approx. 2.3 g/cm<sup>3</sup>, a 10-30 µm thick, dense and crack-free coating is not possible. Therefore, metallic or ceramic fillers are added to the polymer, for example in a
- 25 proportion of 30-50% by volume, in order to deliberately control the phase transformation of the polymer and the crack formation which are taking place and to minimize or eliminate the thermomechanical stresses caused by different coefficients of thermal
- 30 expansion at the interface between metal (turbine blade 1) and masking layer 25.

The required thermal stability of the masking layer is provided by the thermal phase transformation of the

35 polycarbosilane into the corresponding high-temperature-resistant SiOC or graphite phase.

During the coating process, a material 22 is applied to the main blade region 13 of the turbine blade 1 and to the masking layer 25. The material 22 reacts with the  
5 reactive layer 34 to form a reaction layer 43, i.e. to form a material which is able to withstand high temperatures but,

for example, is soluble in water, i.e. can easily be removed.

5 The material 22 is, for example, aluminum, which is applied to the turbine blade 1 in order to form an aluminide layer. An aluminide layer of this type can be applied by plasma spraying or processes as described in EP patent 0 525 545 B1 and EP patent 0 861 919 B1.

10 In the case of aluminum, the carbon of the reactive layer 34 reacts with aluminum to form  $Al_4C_3$ . If the main blade region 13 is completely coated, the entire blade, in particular the securing region 7, can be introduced into water, with the result that the water-soluble  
15 reaction layer 43 which has reacted with the material 22 is dissolved.

The underlying layers 28, 31 can easily be removed by dry ice blasting, and consequently the removal processes do not cause any change in the geometry in  
20 the securing region 7. Aluminum is applied to a turbine blade 1 during refurbishment for example, i.e. inter alia during removal of used MCrAlY layers.

As an alternative to the three-layer structure shown  
25 here by way of example, the masking layer 25 may also be a gradient layer which has a graduated structure, i.e. on the substrate 40 the composition is selected in such a way as to allow good bonding, and at the outer surface the composition is such that it reacts with the  
30 material 22 of layers which are yet to be applied.

Figure 4 shows a component according to the invention in the form of a turbine blade 1 having a masking layer 25.



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A ceramic layer 37, which forms the masking layer 25,  
is applied direct to the, for example, metallic turbine  
blade 1.

This ceramic layer may, for example, be an oxide ceramic which is matched to the coefficient of thermal expansion of the substrate.

There are no further layers, in particular no bonding  
5 layers, between the ceramic layer 37 and the metallic  
substrate 40 of the turbine blade 1, and consequently  
the ceramic layer 25, 37 can be removed by gentle  
introduction of energy, such as for example sand  
blasting or dry ice blasting. The dense ceramic  
10 layer 37 also forms a diffusion barrier during a  
process of coating the turbine blade 1 with other  
layers, such as for example bonding layers or thermal  
barrier coatings.

15 The masking layer 25 may also only react with the  
material 22 of layers which are yet to be applied, for  
example to form a brittle layer 43, for example a  
ceramic layer 37. The ceramic layer 37 may also form  
only after a further heat treatment (pyrolysis), by way  
20 of example.

Brittle layers 43 of this type can be removed by simple  
processes, such as thermal shock processes or sand  
blasting or dry ice blasting, i.e. by blasting  
processes which introduce energy but do not have an  
25 abrasive action.

It is particularly advantageous if the masking layer 25  
reacts with the material 22 of layers which are to be  
applied to form a water-soluble layer 43.

30 Further layers may in this case be present beneath the  
top layer of the masking layer, i.e. the masking layer  
25 may be a multilayer structure. In this case, it is  
possible for a joining layer to be applied direct to  
35 the substrate 40 of the coated component and for a  
gradient layer also to be applied, allowing matching to

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coefficients of thermal expansion, so that the masking  
layer 25 remains crack-free

even during masking, and consequently it is impossible for any material to reach the substrate 40 of the component which is to be coated.

5 Figure 5 shows a turbine blade 1 having a substrate 40 to which a masking layer 25 has been applied. The material of the masking layer does not react and diffuse with the material of the substrate 40 at the elevated temperatures of the coating process.

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During the coating process, material 22 comes into contact with the masking layer 25 and reacts with the latter. The reaction may also take place in a subsequent heat treatment, if the reaction temperature is higher than the substrate temperature during the coating operation. The reaction layer 43 which is formed in this way (Fig. 6) can easily be removed again following the process of coating the turbine blade, since it is, for example, brittle or water-soluble. The material 22 therefore also comes into contact with the unmasked regions of the substrate 40 of the turbine blade 1 and forms a desired coating 55 (Fig. 6).

Figure 7 shows a water bath 46 into which a turbine blade having a water-soluble layer 43 has been introduced. Its water solubility allows the layer 43 to be removed easily, so that after the turbine blade 1 has been taken out of the water bath an uncoated part and a desired coated part 55 of the turbine blade 1 are present. The reaction layer 43 may also be removed by water blasting, in which case once again small a amount of energy is introduced.

The, for example, brittle reaction layer 43 may also be removed by the introduction of energy from a blasting gun 49 (ultrasound, dry ice blaster, sand blaster) (Fig. 8).